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The effectiveness of after-school interventions at increasing moderate-to-vigorous physical activity levels in 5-18 year olds: a systematic review and meta-analysis

Authors
Ruth Mears[1,2] and Russell Jago[2].
[1] Centre for Academic Primary Care, School of Social and Community Medicine, University of Bristol, 39 Whatley Road, Bristol, BS8 2PS, United Kingdom.
[2] Centre for Exercise, Nutrition and Health Sciences, School for Policy Studies, University of Bristol, 8 Priory Road, Bristol, BS8 1TZ, United Kingdom.
Email: russ.jago@bristol.ac.uk, rm14101@bristol.ac.uk
Telephone number: (0) 117 954 6603, (0) 117 951 1058

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ABSTRACT

Aim: Physical activity in children improves cardiovascular, mental, metabolic and skeletal health. Many children fail to meet the national recommendation of at least 60 minutes per day of moderate to vigorous physical activity (MVPA). After-school programmes provide an opportunity to engage children in physical activity. This systematic review and meta-analysis examines the effectiveness of after-school interventions at increasing MVPA levels in children and adolescents.
Design: Systematic review and meta-analyses
Data sources: A literature search was conducted using Medline, EMBASE and PsychINFO databases from January 1950 to April 2015.
Eligibility criteria for selecting studies: Inclusion Criteria – *Population:* Participants aged 5-18 years. ***Intervention:*** An after-school programme in a school-based setting as the main component of an intervention to increase physical activity levels. ***Outcomes:*** Individual level measure of time spent in MVPA. ***Study Design:*** Quasi-experimental, pilot, non-randomised or randomised trials. **Exclusion Criteria:** Conference abstracts, unpublished articles, dissertations and non-English language papers.
Results: 1387 records were identified through database searching. After removal of duplicates, there were 748 records. 15 articles met the inclusion criteria for the systematic review. Six studies were eligible for meta-analysis and the pooled intervention effect at end-point follow up was 4.84mins/day of MVPA (95% CI -0.94 to 10.61). The effectiveness of afterschool interventions varied considerably and comparisons between studies limited by different methodological study designs. Sub-group analyses within a small minority of studies revealed significant benefits in overweight/obese children and boys. There was a lack of convincing evidence that interventions based on theories of behaviour change were more effective than those with no underlying theory.
Conclusion: After-school physical activity interventions to date have had mixed effectiveness on increasing MVPA levels. More robust evaluations of extra-curricular physical activity interventions are required, particularly studies that use objective assessment of physical activity.

INTRODUCTION

The health benefits of physical activity for school-aged children include reduced adiposity, improved cardiovascular fitness, academic performance, mental health, skeletal health, lipid levels and blood pressure.[1-4] Physical activity levels in childhood predict adult physical activity levels.[5 6] Regular adult physical activity has been shown to reduce the risk of coronary heart disease, stroke, diabetes, hypertension, breast and colon cancer, depression and osteoporosis.[7 8] Many children fail to meet the national recommendation of at least 60 minutes per day of moderate to vigorous physical activity (MVPA).[9] Developing strategies to increase physical activity levels is critical to reduce the co-morbidity and mortality associated with inactivity.[10]

After-school (extra-curricular) programmes provide an opportunity to engage children in physical activity[11] but evidence supporting their effectiveness has been mixed.[12-14] Strategies to increase PA levels in this time-period include the adaptation of existing after-school programmes, single sport specific interventions and multi-component interventions.[12-14] The school-based setting has potential to provide a cost-effective site for a physical activity intervention [15 16] as transport of children to the site is not required, resources are readily available and staff may be willing to be trained for involvement in the programme providing a potentially sustainable option. Two systematic reviews in 2011 provide further support for focusing on the school-based setting. Atkin et al [12], report that effective studies were mainly based in schools rather than the community though this review did not include a meta-analysis. A separate review [17] reported on the positive efficacy of school-based interventions [17], though this review was not limited to the afterschool time period.

Systematic reviews enable the results of multiple studies to be integrated to synthesise a higher level of evidence and provide objective critical appraisal of the literature to date. There have been several previous reviews of after-school interventions but these were conducted in 2009 and 2011 and therefore require updating in order to ensure that they remain relevant.[12-14] Previous reviews of after-school physical activity interventions have included studies with group-level outcome measures (e.g. System for Observing Fitness Instruction Time – SOFIT[18]) as well as individual-level outcome measures which makes comparison across studies difficult and they have been limited to narrative reviews. Reviews have also been limited by a focus on all forms of activity with studies that included measures of volume of activity but not time spent in a moderate-to-vigorous intensity of physical activity. This limitation is important as current public health guidance in the UK, USA, Europe and many other countries is based on minutes of MVPA. None of the previous reviews have reported on the extent to which theories of behaviour change have underpinned the intervention design, which is an important omission as theory based interventions and theory based derived mediators of behaviour change are now considered to be best practice for intervention design.[19-21] As such, understanding how interventions were intended to function is important for assessing the factors that may have affected intervention effectiveness.

The primary aim of this systematic review was to examine the effectiveness of after-school interventions at increasing MVPA levels in children and adolescents using a meta-analysis

approach where possible. The secondary aim was to report on intervention design, based on theories of behaviour change.

METHODS

Search Strategy

A literature search was conducted using Medline, EMBASE and PsychINFO databases from January 1950 to April 2015. The search strategy included the following search terms relating to children (MeSH terms 'Child' and 'Adolescent', free text words 'child*' or 'teenager*' or 'adolescent*'), afterschool (free text terms 'after school' and 'extra-curricular') and physical activity (MeSH terms 'sports' and 'exercise', free text word 'sport*', 'exercise*' and 'physical activity'). Retrieved titles and abstracts were screened and the full text obtained for potentially eligible articles. References cited within the included studies and relevant review articles were also examined using the inclusion and exclusion criteria to assess for eligibility. Results were reported in accordance with PRISMA guidelines [22].

Inclusion Criteria

Population: Participants aged 5 to 18 years.
Intervention: An after-school programme in a school-based setting as the main component of an intervention to increase physical activity levels.
Outcomes: Individual level measure of time spent in MVPA.
Study Design: Quasi-experimental, pilot, non-randomised or randomised trials.

Exclusion Criteria

Conference abstracts, unpublished articles, dissertations and non-English language papers were excluded.

Data Extraction

A reviewer (RM) extracted data from included papers which was checked by a second reviewer (RJ). Discrepancies between the data were resolved through discussions. The data extracted has been summarised in Table 1.

Assessment of Study Quality

Critical appraisal of study quality was conducted by a reviewer (RM) using an adapted version of the 'Quality Assessment Tool for Quantitative Studies.'[23 24] This tool was selected due to the nature of the review including a range of different quantitative study designs. A second reviewer (RJ) also appraised the included studies and discrepancies were resolved through discussion. The reliability and validity of this tool has been documented by the 'National Collaborating Centre for Methods and Tools' and it is deemed of strong methodological rating.[25] Selection bias, study design, blinding, data collection, withdrawals and drop outs, intervention integrity and statistical analyses were appraised and each given a rating of weak, moderate or strong.

Qualitative Synthesis

For the qualitative section of the systematic review synthesis was discussed amongst the authors until consensus was reached. A reviewer (RM) wrote the initial qualitative synthesis and this was checked and amended by the second reviewer (RJ).

As the included studies provided some evidence of differences by gender and body mass index at baseline we conducted an additional qualitative synthesis of differences by these sub-groups.

Meta-analysis

To minimise heterogeneity within the meta-analysis, studies were only included if they measured the same outcome measure (adjusted difference in means of MVPA in the intervention group compared to the control group at follow-up). Random effects meta-analyses were performed in STATA version 11 (Statacorp, College Station, Texas) for these studies. The chi-squared test was used to assess statistical heterogeneity. Statistical heterogeneity (I^2) provides a quantitative estimation of the clinical heterogeneity and/or methodological heterogeneity within included studies in the meta-analysis. Heterogeneity was further minimised by conducting additional separate meta-analyses for accelerometer-only studies.

The first meta-analysis examined baseline to end-point data for accelerometer studies (where end-point data is defined as data collected at a time-point closest to the end of the intervention). The second meta-analyses included self-report studies and examined baseline to end-point data. The third meta-analysis focused on data from baseline to initial follow-up data collection point for accelerometer studies (where initial follow-up data collection point is defined as the first follow-up data collection point after baseline). A further analysis included self-report studies and examined baseline to initial follow-up data collection point.

RESULTS

Literature search

In total, 1387 records were identified through database searching. Fifteen papers met the inclusion criteria. One paper was identified via the references cited from an included study. Figure 1 provides an overview of how papers were identified, included and excluded in accordance with the PRISMA guidelines.[22]

Participant characteristics

Supplementary Table 1 summarises participant and study characteristics. The majority of studies were conducted in the USA with only two UK based trials.[26 27] The total number of participants enrolled in each trial varied from 13 to 1422.[28 29] Only one study involved children younger than 8 years old.[30] The oldest child enrolled in a study was 15 years old.[31] Some studies targeted specific populations such as African-American or Black children in three studies[31-33], BMI > 85th percentile in one study [34] and females in three studies.[26 33 35]

Study characteristics

There were nine randomised controlled trials[26 27 29 31-34 36 37] including five pilot RCTs[26 27 31 34 38] and one cross-sectional RCT[36]. The remaining six studies were quasi-experimental[39 40 41], longitudinal[42 43] and cross-sectional[44]. The nature of the after school physical activity component of the intervention included structured or unstructured play, planned MVPA,

multi-sport physical activities, single sport physical activity programme (e.g. soccer or dance offered alone) or adhering to specific principles such as the SPARK or CATCH Kids Club curriculum or the YMCA environmental change principles.

Study quality

The methodological critical appraisal of studies included in the systematic review is summarised in Figure 2 and those included in the meta-analysis is summarised in Figure 3. No studies demonstrated that participants who consented and participated in the trial were similar in baseline demographics and activity levels to those who did not. Although Iverson et al attempted to minimise bias by randomly selecting six schools from 115 schools for participation, they failed to report the percentage of eligible students within these schools who agreed to engage in the study.[42] Jago et al was one of the few studies to attempt to compare trial participants to that of the general population.[26] There was no difference in BMI but trial participants engaged in 19.5 fewer minutes of MVPA per day (33.2 vs 52.3) at baseline than those of a similar demographic.[26]

Withdrawal and drop-out rates were less than 20% in eight of the studies[26 29 32 34 36 37 39 44], however, mean programme attendance was less than 50% or not reported in five of these studies[34 36 37 39 44]. Most studies failed to measure the consistency of the intervention delivered with only one study describing an 'independent evaluator systematically observing after-school programme activities to assess the fidelity of intervention implementation, delivery and reach.'[29] Some studies reviewed written documentation by intervention staff regarding on-site activities.[30 32] Sample size calculations were absent in six studies.[29 30 33 39 43 45] Where the unit of allocation and unit of analyses differed, almost all studies took account of clustering in their analysis.

Outcome Measures

MVPA was measured by accelerometers in twelve studies[26 27 29-32 34-37 39 44], heart rate (HR) monitor in one study[28] and self-report in two studies[33 42] (Table 2). There was little consistency in the unit of measurement utilised for MVPA with studies reporting hours[33] or minutes per weekday[26 39] or day[29-31 34 36], minutes per after-school time period [37], minutes per hour [35], minutes per intervention session[44], minutes per week[42] and percentage lesson time in MVPA[28]. Sub-group analyses according to BMI or sex were reported in a minority of studies.[27 36 37 39 42 45] The majority of studies reported MVPA at baseline and at the end of the intervention time period. Only two studies provided an indication of the long-term impact of the intervention, measured by MVPA data recorded over four weeks after the intervention had ceased (Table 3).[26 27]

Theories of behaviour change

Eight studies (53%) reported that the design was based on an underpinning theory of behaviour change. The most commonly reported theory of behaviour change was social cognitive theory, which was used in four studies[29 31 32 36] (Table 4). Three studies involved self-determination theory[26 27 29], two studies an ecological approach[30 36] , one study the health promotion model[41] and one study strategic self-presentation.[31] Studies based on a theory of behaviour change were effective at significantly increasing overall physical activity levels across all participant subgroups at all time-points in one study,[30] at mid-intervention only in one study[29], at 3 months after the intervention had ended in one study[26], for boys

only in one study[46] and ineffective in achieving any significant difference in MVPA in two studies.[32 35] One intervention with no underlying theory of behaviour change specified was effective at increasing overall physical activity levels across all participant subgroups at all time-points,[33] one at mid-point only[47] and two within certain sub-groups[37 42].

Impact of intervention on MVPA

Table 5 summarises the effect of the intervention on MVPA. The greatest difference in mean MVPA (22.2 mins/day, 95% CI 9.6 to 34.2, p-value 0.0006) was reported by Barbeau et al, though this data was collected through self-report.[33] From accelerometer based data, the largest significant mean difference in MVPA from baseline to end of intervention in the intervention group versus the control group was 10.5mins/day (95% CI 1.5-18.6, p-value 0.017).[30]

Difference in means of MVPA for sub-groups

MVPA levels did not significantly change amongst all participants in each study. Sub-group analyses within certain studies however revealed significant differences.[27 37 42 44] Table 6 provides a summary of included studies that have conducted a separate analysis examining the impact of the intervention on MVPA according to gender and/or weight status.

Difference in means of MVPA at specific time-points only

Wilson et al reported 4.87mins/day (95% CI 1.18 to 8.57, p-value <0.05) more MVPA in the intervention group at mid-intervention though this significant effect was lost at follow-up 2 weeks after the intervention had ceased.[29] Weintraub et al similarly noted a dwindling effect of the intervention from a significant difference of 10.57mins/day (95% CI 1.42 to 19.73, p-value 0.03) at 3 months to a non-significant difference of 3.02 minutes (CI -3.68 to 9.72, p-value 0.36) at 6 months (endpoint of the intervention).[34] Jago et al reported a post-intervention effect (3months after intervention ceased) of 8.7mins/weekday more MVPA (95% CI 5.5 to 11.9) in the intervention group.[26]

No difference in MVPA

Three studies reported no difference in means of MVPA in any of the participants.[31 32 39] One of these was a pilot study.[32] One study reported a non-significant positive trend towards a greater change in MVPA levels in the intervention group at follow-up.[35]

Meta-analysis

Six studies were eligible for inclusion in the meta-analysis.[29 33 40 46-48] Five of these studies used an objective measure of MVPA (accelerometry)[29 40 46-48] and one study used a self-report measure of physical activity.[33]

The first meta-analysis (Figure 4) focused on accelerometer based studies and examines the adjusted mean difference in mins/day of MVPA in the intervention versus the control group from baseline to end-point follow-up (where end-point follow-up is defined as data collected at a time-point closest to the end of the intervention). There was an effect size of 2.57mins/day of MVPA (95% CI -1.74 to 6.87) and I-squared value of 44.8%.

The second meta-analysis (Figure 5) includes all 6 studies (five accelerometer, 1 self-report) studies and again examines the adjusted mean difference in mins/day of MVPA in the

intervention versus the control group from baseline to end-point follow-up. There was an effect size of 4.84mins/day of MVPA (95% CI -0.94 to 10.61) and I-squared value of 70.4% (Figure 5).

The third meta-analysis (Figure 6) focuses on accelerometer based studies and examines the adjusted mean difference in mins/day of MVPA in the intervention versus the control group from baseline to initial follow-up point (where initial follow-up data collection point is defined as the first follow-up data collection point after baseline). The initial follow-up data collection point was at mid-intervention for two studies and at the end of the intervention for three studies. There was an effect size of 5.18mins/day of MVPA (95% CI 0.75, 9.62) and I-squared value of 46.4%. A further analysis including the self-report study resulted in an effect size of 7.04mins/day of MVPA (95% CI 1.59 to 12.5) and I-squared value of 65.5.%.

DISCUSSION

Main findings

This systematic review found considerable variation in the effectiveness of after-school physical activity interventions, with comparisons between studies limited by different study designs. Studies reporting a beneficial effect on MVPA across all sub-group of participants were often limited in terms of precision by wide confidence intervals. The only meta-analyses demonstrating some evidence of a difference in MVPA were those which included mid-intervention data instead of end-intervention data for two studies. However, as mid-intervention data was only available for two of the studies in the meta-analyses, caution is needed regarding the strength of evidence supporting a beneficial change in MVPA from baseline to mid-point versus baseline to end-point of the intervention.

Sub-group analyses within a small minority of studies revealed specific benefits in overweight/obese children[37 36 42] and boys in two studies.[27 45] These findings suggest that adaptations to content to suit the needs of particular groups may be needed. However, due to the small number of studies undertaking sub-group analyses and the lack of consistent methodology for these analyses, the significance of sub-group differences should be interpreted cautiously until further evidence is available.

There was a lack of convincing evidence that interventions based on theories of behaviour change were more effective than those with no underlying theory.

Possible explanations

The potential of after school programmes to influence MVPA levels may be understood more fully by studying potential effective components within an intervention strategy. Barbeau et al reported a mean difference in MVPA between control and intervention groups of 22.2mins per day (95%CI 9.6 to 34.2), though this was through self-report measures.[33] One strategy employed by Barbeau et al, was to provide immediate feedback to participants on whether they were achieving sufficient intensity of exercise during a session using HR monitors and teaching participants on maintaining a HR of above 150bpm. Ignico et al also utilised the concept of children 'self-regulating activity intensity to stay within a target heart rate zone' and reported this to be the motivating force behind the 38 minutes (95 % CI NR) of MVPA reported per intervention session.[28] A separate study specifically examined the use of heart-rate feedback to increase physical activity in children and demonstrated a significant increase in vigorous physical activity levels.[49]

It is important to note that Barbeau and colleagues randomised students within schools to intervention or control group at the individual level. This potentially minimised the effect of any concurrent school physical or educational factors that may influence MVPA levels and contaminate the intervention or control groups. Weintraub et al also randomised at the individual level and the study reported the intervention group to obtain 10.57mins/day of MPA (95% CI 1.42 to 19.73) more than the control group mid-intervention, though this significant difference was lost at 6 months.[34] The majority of other trials randomised at the school level. [26 27 29 30 36 37 39] Although measures were taken to try and control the potential confounders through adjustment for cluster level effects, different schools with different

characteristics have already been selected and the objective of randomisation potentially diminished by unknown confounding variables.[50]

Some studies identified positive changes in overweight/obese children[36 37] or the 'at risk' population defined by Iverson et al as those with a BMI > 85th percentile, PA less than 300 minutes per week or less than five fruit and vegetable servings per day.[42] A previous study has reported that obese children tend to be less active than non-obese children particularly outside of school time.[51] Given this research, it is possible that an afterschool physical activity program may replace a normally sedentary time for obese children and active time for non-obese children thus explaining the potential discrepancy in effect between these sub-groups. Of note, the only intervention within this review specifically targeting obese children was found to be effective at the mid-intervention point, though the sample size was small, the confidence interval large and the effect was lost by the end of the intervention time period.[34] Madsen et al recorded overweight and obese students attending more sessions than normal weight students (60% vs 39%, 95% CI for difference, 2-38) potentially indicating that it may be feasible to target this weight group.[37]

The analysis also showed that there may be some evidence of a gender difference with greater effect on the MVPA of boys. Jago et al found that boys in the intervention group obtained 8.6 mins more of weekday MVPA than the control group (95% CI 2.8 to 14.5), with no evidence of an effect for girls.[27] Similarly, Schuna et al found that boys achieved greater MVPA levels than girls in the Keep It Moving (KIM) afterschool programme.[44] This difference between boys and girls has been reported elsewhere in the literature,[52 53] though the reasons underlying this remain unclear. This finding suggests that there is a particular need to find ways to increase girls MVPA during extracurricular interventions.

Interventions in context of daily physical activity levels

Data from the Avon Longitudinal Study of Parents and Children (ALSPAC) showed that the highest peaks of physical activity within a day occurred during the afterschool time period.[54] Afterschool programmes may therefore occur within an already active time period where children are already engaging in physical activity, resulting in minimal change in overall daily MVPA levels with the intervention. This may explain why the study by Gortmaker et al was successful (MD 10.5mins of MVPA per day, 95% CI 1.18 to 8.57) as it targeted children already enrolled in an after school programme and aimed to optimise physical activity through modification of this program through a set of environmental standards.[30] This meant that the setting the children were in had not changed but optimisation of this setting had taken place potentially leading to higher rates of sustainability of the intervention. Further observational studies examining what activities active children do and where they engage in these activities in the after school time period may be useful to consider when developing strategies to engage less active children in physical activity. The focus on whether to develop pre-existing afterschool programmes or create new research programmes may depend on country-level factors. In the USA, for example, afterschool programmes (e.g. YMCA) are more widespread than the UK and are used as a form of aftercare for working parents. This suggests that interventions targeted at this population may reach a different population to that of newly created physical activity afterschool programmes. However, given the contextual difference, where there is a lack of current provision there is a clear need to create, optimise and evaluate new programmes.

It is important for studies to clearly identify the target population for their intervention and the clinically relevant outcome they are trying to achieve within this target population. For example, Herrick et al noted that participants in their study were already achieving an average of 21 minutes of MVPA in the after-school period and nearly 60 minutes of total daily MVPA at baseline questioning the clinical relevance of an intervention within this population.[39]

Long-term effect

There is a lack of data regarding the long-term impact of an intervention on MVPA with only two pilot studies measuring MVPA 3-4 months after the intervention had ceased.[26 27] Jago et al reported 8.7mins more MVPA per weekday (95% CI 5.5 to 11.9) in the intervention group three months after the intervention had ceased compared to a control group. Interestingly, they did not find a difference between the same groups in the last couple weeks of the programme.[26] This conflicting effect may be explained due to the nature of the study as a pilot feasibility trial, not powered to detect group differences.

The longest follow-up time period of studies reporting favourable intervention effects on MVPA was 2 weeks after the intervention ceased.[29] In this study, the beneficial effect of the intervention at midpoint was lost two weeks post-intervention.

Weintraub et al also measured MVPA at two time-points (mid-intervention and end of intervention).[34] They found a reduction in intervention efficacy as time progressed from 3 months to 6 months. This may be associated with a decline in mean attendance at the intervention soccer group from 53% in the first 3 months to 35% for the second 3 months. Considering there was only a total of 9 students, this implies that some sessions in the latter part of the programme involved very few participants only.

Limitations

Several afterschool school-based physical activity intervention studies did not meet the inclusion criteria for the review as they did not specifically measure MVPA levels but instead used other measures of physical activity. Despite included studies all measuring MVPA levels, the lack of consensus in reporting units of MVPA made direct comparison of studies difficult. Some studies only reported MVPA achieved during the intervention session alone [28 44]. As such, it is difficult to then comment on the overall effect of the intervention on a child's physical activity levels as the intervention may be replacing a more active or less active time period. The meta-analysis was limited to a small number of studies which measured the adjusted mean difference in minutes per day of MVPA in the control group versus the intervention group. This limitation highlights the importance of consistency in reporting measures of MVPA to allow for future meaningful comparisons on the efficacy of interventions to be made and progress the literature forward.

It is also important to highlight that there was variance in the accelerometer cutpoint used for MVPA. This may lead to differing interpretations of an interventions' effectiveness. A previous study evaluating the accuracy of the various accelerometer cutpoints recommended that Evensons cut-points should be used.[55] There seems to be little conclusive evidence regarding the number of days an accelerometer should be worn in

order to accurately calculate daily MVPA levels, with included study protocols ranging from 3 days to 7 days. Additionally, the definition of non-wear time and criteria for inclusion in analysis varied across studies.

In this review, 'post-intervention' MVPA was defined as an outcome measure of MVPA taken >4 weeks after the intervention had ceased. This outcome measure is less relevant for studies which aim to provide and maintain physical activity through a structured ongoing afterschool programme than for those studies aiming to promote physical activity seeking behaviour change which persists after an intervention has ceased. There is a need to identify programmes that children will attend and which can increase MVPA in a sustainable way. This could either be via improving current afterschool provision or where no provision exists adding new programmes that are shown to be effective.

Critical appraisal of studies using the 'Quality Assessment Tool for Quantitative studies' revealed certain aspects of study design which were poorly conducted by many of the studies. The majority of studies did not assess the fidelity of intervention implementation which may mean that the intervention was not delivered in the format it was designed or in accordance with the theory of behaviour change. Studies also often failed to report or demonstrate good levels of attendance to their intervention. This may explain the small or negligible effect of most interventions on MVPA but also the lack of difference in effectiveness of those interventions based on a theory of behaviour change compared to those with no theoretical basis.

In several studies [29 34] the control group was provided with a programme which may have been more sedentary than the activities which they would normally have engaged in during the afterschool time period. This may result in the effectiveness of the intervention at increasing MVPA levels to be overestimated.

The only meta-analyses providing some evidence of a difference ($p < 0.05$) in MVPA examined the adjusted mean difference in mins/day of MVPA in the intervention versus the control group from baseline to initial follow-up point. However the Chi-squared test for accelerometer based studies indicated moderate statistical heterogeneity (46.4%) and when self-report studies were also included, the Chi-squared test was 65.5% signifying substantial statistical heterogeneity. The heterogeneity observed in the meta-analyses is likely due to the variation in methodological approaches between the different studies.

Future Directions

Given that the desired clinically relevant outcome endpoint is an increase in daily MVPA levels, it would seem sensible to report change in MVPA in terms of mins/day. In order to fully understand the potential benefits of translation of this research into clinical practice, in terms of children meeting national and WHO recommendations for MVPA, another endpoint that future studies may wish to consider reporting, would be the percentage of participants achieving 60mins of MVPA per day at baseline and follow-up.

This review has focused on school-based interventions but there is clearly a role for interventions within other settings. Further reviews exploring the influence of the

intervention setting on efficacy, sustainability and cost-effectiveness are needed. Specifically, interventions targeted at enhancing existing programs may require alternative theories of behaviour change that focus on increasing capacity among staff as opposed to individual behaviour change.

Sub-group analyses needs to be interpreted with caution as studies may conduct these analyses after no intervention effect was found and therefore the study may not be statistically powered to determine the effects on sub-groups. Future studies need to be clear in their intervention design of the statistical analyses they intend to perform and ensure that they are adequately powered to answer the research question posed.

Contextualisation

A systematic review from 2009 by Beets et al concluded that after school programs can be effective at improving physical activity levels with a meta-analysis indicating an effect size of 0.44 (95% CI 0.28, 0.60).[13] A separate review by Pate et al reported mixed findings with regard to the effectiveness of afterschool interventions at increasing physical activity.[14] Atkin et al found only three of the nine studies within their review to be effective.[12] There is some evidence for physical activity interventions[56] not confined to the after school-time period though these only had a small effect on overall physical activity.[57] No other reviews have commented on sub-group analysis of overweight/obese children or theories of behaviour change.

CONCLUSION

This meta-analysis and systematic review has found that after-school physical activity interventions to date have had mixed effectiveness on increasing MVPA levels. The meta-analyses provided some evidence supporting a difference ($p < 0.05$) in MVPA when mid-intervention data from two studies were used instead of end-intervention data. However due to only two studies included in the meta-analyses measuring mid-intervention data, this finding warrants further investigation.

The qualitative synthesis has identified that overweight/obese children may show significant changes in MVPA levels compared to controls even when there is no significant change in MVPA in the intervention group as a whole. Due to the lack of sub-group analyses in many of the included studies, this finding needs to be interpreted with considerable caution and further exploration of sub-groups with adequately powered studies is warranted. Similarly, the few studies indicating that boys may benefit to a greater extent than girls from an intervention also needs to be investigated more robustly and extensively. It is also important to understand the reasons for this potential gender difference in order to develop strategies to adapt content to increase impact on girls and non-overweight children.

The secondary aim of the review was to report on intervention design based on theories of behaviour change. In this review, the presence or absence of a stated theory of behaviour change underlying an after school intervention had no convincing effect on the effectiveness of the intervention. This may be due to the large number of factors contributing to whether an intervention yields a change in physical activity.

What are the new findings?

- There is mixed evidence supporting the effectiveness of afterschool physical activity interventions at increasing MVPA but current evidence is of variable study design making comparisons difficult.
- A small number of previous programmes have had more effect on overweight/obese children and boys.
- There is limited evidence supporting the use of any single theory of behavioural change as the basis for an intervention.

How might it impact on clinical practice in the near future?

- After school programmes may provide an opportunity for children to increase their MVPA levels and help tackle the fourth leading risk factor (physical inactivity) for global mortality as identified by the WHO[8].

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Table 1 Data Extraction

Study Characteristics	Study design, location, target population, participants, nature of intervention
Theory of behaviour change	Any theory of behaviour change which the authors report is underpinning the intervention.
Time points of MVPA measurements	Baseline, during or <4 weeks after intervention, >4 weeks after intervention completed
MVPA Outcome Measure	Difference in means of MVPA (from baseline to follow-up) or adjusted difference in means of MVPA (between control and intervention group at follow-up) or MVPA achieved in an intervention session (where no baseline measurements have been taken). MVPA measurements were extracted as minutes per day where data allowed.

Table 2 Physical activity assessment

	Accelerometry	**HR monitor**	**Self-Report**
Schuna et al, 2013	✓		
Barbeau et al, 2007			✓
Herrick et al, 2012	✓		
Jago et al, 2012	✓		
Dzewaltowski et al, 2010	✓		
Jago et al, 2014	✓		
Madsen et al, 2013	✓		
Wilson et al, 2011	✓		
Gortmaker et al, 2012	✓		
Robbins et al, 2012	✓		
Story et al, 2003	✓		
Weintraub et al, 2008	✓		
Iversen et al, 2011			✓
Ignico et al, 1997		✓	
Wilson et al, 2002	✓		

Table 3 MVPA Measurement Points

	Baseline	**Mid-Intervention**	**End of Intervention**	**Post-intervention effect +**
Schuna et al, 2013		✓		
Barbeau et al, 2007	✓		✓	
Herrick et al, 2012	✓		✓	
Jago et al, 2012	✓		✓	✓ (3 months)
Dzewaltowski et al, 2010	✓	✓	✓	
Jago et al, 2014	✓		✓	✓ (4 months)
Madsen et al, 2013	✓	✓	✓	
Wilson et al, 2011	✓	✓	✓	
Gortmaker et al, 2012	✓		✓	
Robbins et al, 2012	✓		✓	
Story et al, 2003	✓		✓	
Weintraub et al, 2008	✓	✓	✓	
Iversen et al, 2011	✓	✓		
Ignico et al, 1997		✓		
Wilson et al, 2002	✓		✓	

+ Measure to assess post-intervention effect (>4 weeks after intervention has ended)

Table 4 Theory of Behaviour Change

	Social Cognitive	**Self Determination**	**Ecological Approach**	**Pender's Health Promotion Model [58]**	**None specified**
Schuna et al, 2013					✓
Barbeau et al, 2007					✓
Herrick et al, 2012					✓
Jago et al, 2012		✓			
Dzewaltowski et al, 2010	✓		✓		
Jago et al, 2014		✓			
Madsen et al, 2013					✓
Wilson et al, 2011	✓	✓			
Gortmaker et al, 2012	✓		✓		
Robbins et al, 2012				✓	
Story et al, 2003	✓				
Weintraub et al, 2008					✓
Iversen et al, 2011					✓
Ignico et al, 1997					✓
Wilson et al 2002	✓ +				

+ Also used strategic self-presentation theory

Table 5 MVPA Outcome

	Intervention vs control groups adjusted difference in MVPA at follow-up in means (95% CI)		
	Mins per day MVPA	**Mins per weekday MVPA**	**Other unit of MVPA**
Self-report	**Barbeau et al 2007** **22.2** (95% CI 9.6 to 34.2)		
Accelerometer	**Wilson et al 2011**[D] Mid-intervention; 4.87 (95% CI 1.18 to 8.57) 2 weeks post-intervention; 0.25 (95% CI -4.50 to 5.00) **Gortmaker et al 2012**[D] 10.5 (95% CI 1.5 to 18.6) **Weintraub et al 2008**[C] 3 months; 10.57 mins of moderate physical activity (95% CI 1.42 to 19.73) 4.37 mins of vigorous physical activity (95% CI 0.73 to 8.01) 6 months; 3.02 mins per day of moderate physical activity (95% CI -3.68 to 9.72) 1.25 mins per day of vigorous physical activity (95% CI -1.48 to 3.99)	**Jago et al 2012**[B] Last couple weeks of programme; - 6.8 (95% CI -17.9 to 4.1) compared to control 1 - 2.2 (95% CI – 7.8 to 3.5) compared to control 2 3 months after intervention has ended; 8.7 (95% CI 5.5 to 11.9) compared to control 1 -2.4 (95% CI -5.7 to 0.9) compared to control 2 **Jago et al 2014**[B] In last 2 weeks of intervention; Overall: 4.3 (95% CI -2.6 to 11.3) Boys: 8.6 (95%CI 2.8 to 14.5) Girls: 0.15 (95% CI – 9.7 to 10.0) 4 months after intervention ended; Overall: 0.69 (95% CI -3.4 to 4.8)	**Madsen et al 2013**[B] (mins of MVPA after-school) All participants; 0.7 (95% CI – 1.7 to 3.1) **Story et al 2003**[D] (mins of MVPA from 12pm-6pm) 2.9 (95% CI -24.60 to 30.40)

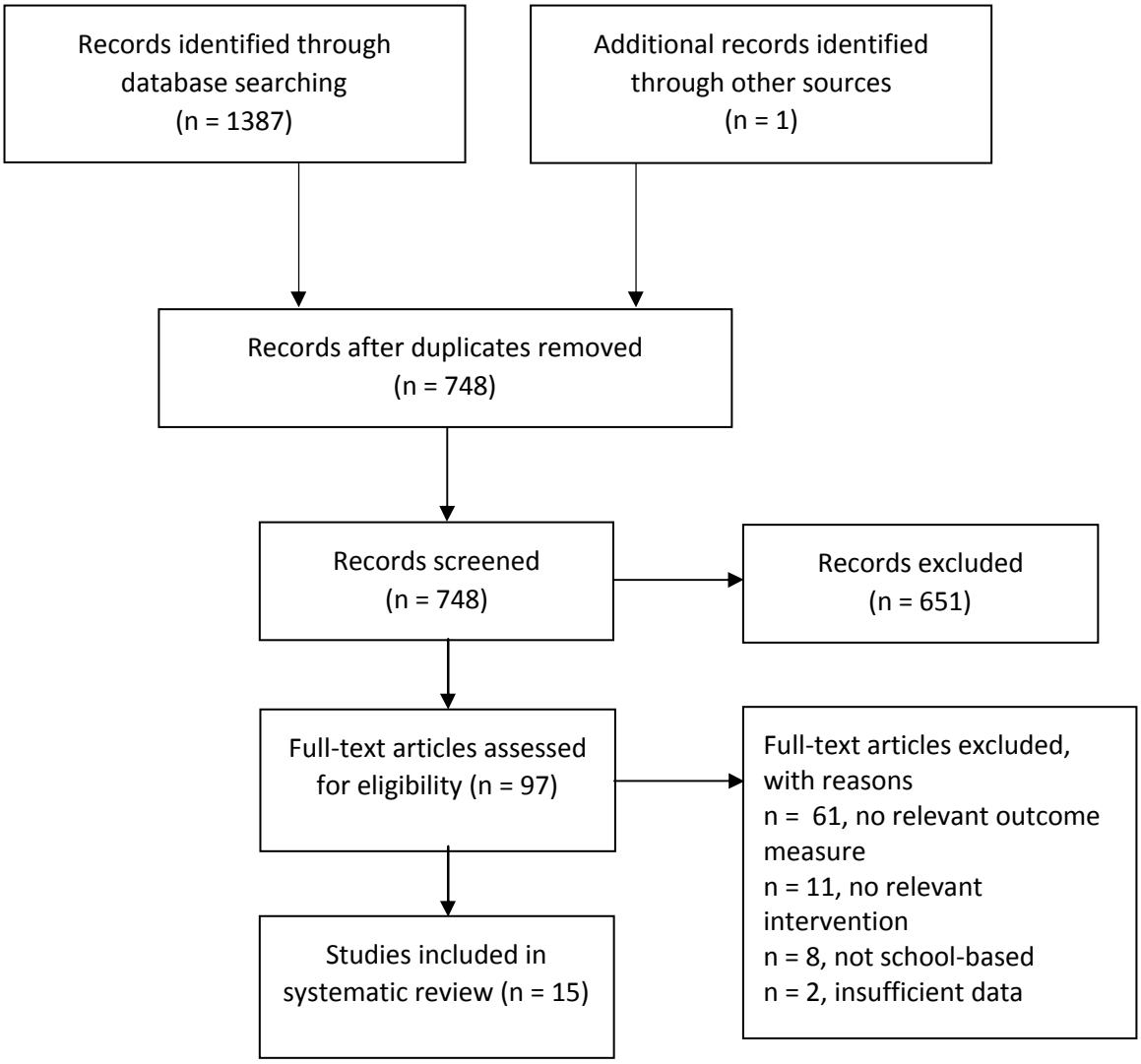
	Change in MVPA from baseline to follow-up for the intervention group (I) and the control group (C) in means (95% CI)		
	Mins per day	**Mins per weekday**	**Other unit of MVPA**
Accelerometer	**Dzewaltowski et al 2010** [A] Overweight / obese children; I: 5.92 C: -9.65 Normal weight children; No significant change.	**Herrick et al, 2012** [B] **I:** 4.5 (95% CI – 2.19 to 11.19). **C:** 4.8 (95% CI -2.93 to 12.53).	**Robbins et al, 2012** [C] (mins of MVPA per hour) **I:** 0.43 (95% CI NR) **C:** 0.07 (95% CI NR) No significant change.
	Other		
	Mins per day	**Mins per weekday**	**Other**
Self-report	**Wilson et al, 2002** No significant change		**Iversen et al, 2011** Overall: 252.35 (SD 220.09) at time 1 and 272.00 (SD 222.62) at time 2 Overweight: 125.26 (SD 76.03) at time 1 and 222.18 (SD 180.90) at time 2
Heart rate monitor			**Ignico et al, 1997** (mins of MVPA per session) 38 (95% CI NR)
Accelerometer			**Schuna et al, 2013** [A] (MVPA per KIM session) Overall; 22.2 (95% CI 17.45 to 26.95). Obese; 21 (95% CI 15.66 to 26.34) Normal Weight ; 23.4 (95% CI 18.63 to 28.17) Boys; 24.7 (95% CI 19.68 to 29.72) Girls; 19.7 (95% CI 14.70 to 24.70)

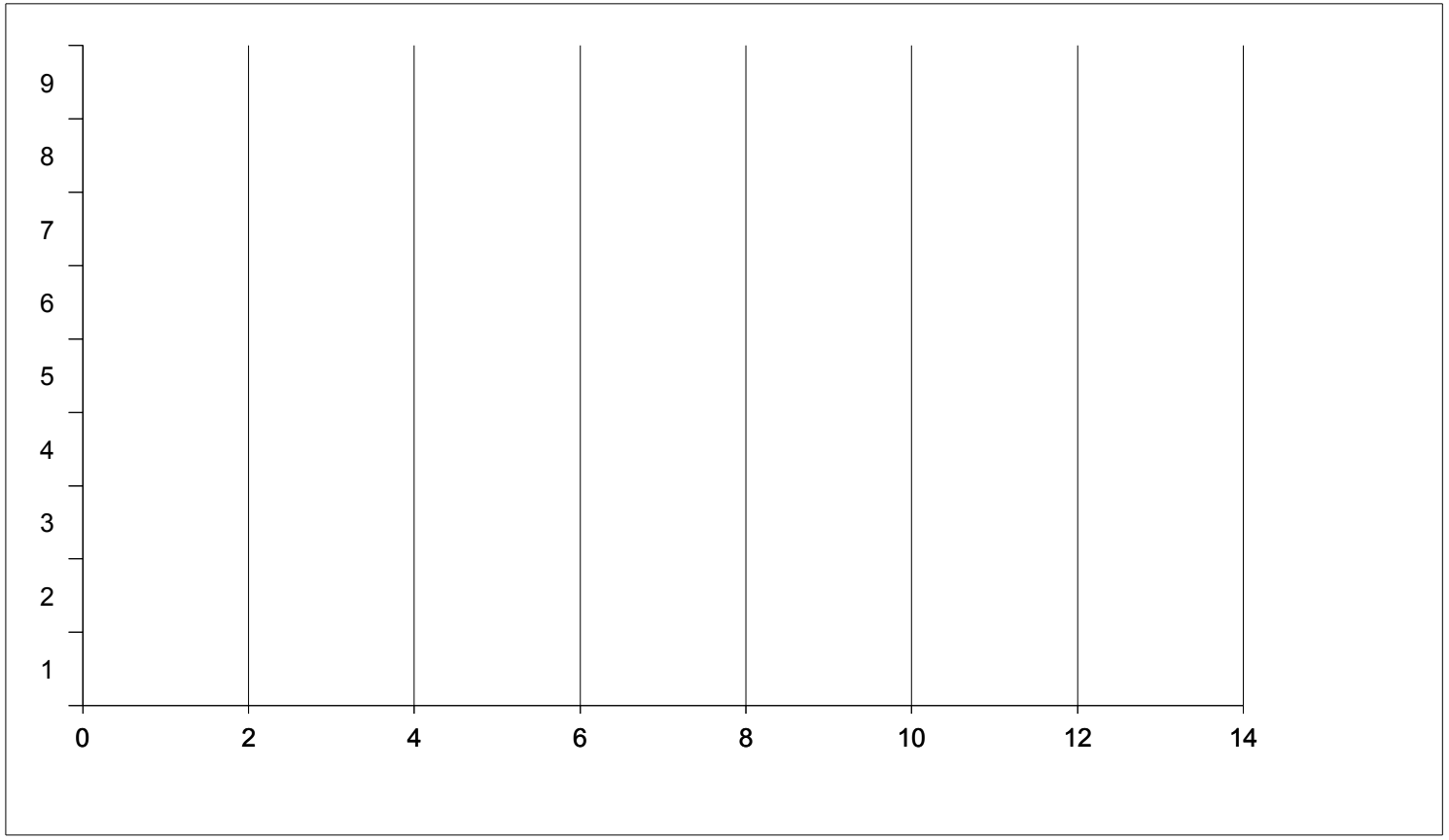
Note: Accelerometer cutpoints used to define MVPA; [A] Freedsons, [B] Evensons, [C] Treuth, [D] Other.

Table 6: Sub-group Analysis by Gender and Weight Status

Subgroup analysed	Author	Finding
Overweight, obese or 'at-risk'	Madsen et al, 2013	In participants with a BMI ≥ 85th percentile at baseline, SCORES significantly increased after-school MVPA by 3.4mins (95% CI 0.3-6.5). When all participants (regardless of weight status) were included in the analysis, there was no significant difference in MVPA.
	Dzewaltowski et al, 2010	Dzewaltowski et al noted a positive effect confined to overweight/obese participants of 5.92 mins/day of MVPA.
	Iverson et al, 2011	Iverson et al found no significant difference in physical activity levels overall but analysed an 'at-risk' sub-group (which they defined as BMI > 85th percentile, physical activity <300minutes per week or <5 servings per day of fruit and vegetables) and found a significant impact of the intervention on MVPA levels in this specific sub-group.
	Gortmaker et al, 2012	Analysis by Gortmaker indicated a marginally larger effect of the intervention for overweight compared with other children.
	Herrick et al, 2012	The SPARK programme had no effect on MVPA in all participants exposed to the intervention regardless of weight status. Similarly, no effect of SPARK on MVPA was identified when results were analysed according to weight status.
	Schuna et al, 2013	No significant differences were found between non-overweight and overweight / obese participants for MPVA. This study only measured MVPA achieved during an intervention session and not change in MVPA. There was no control group.
	Barbeau et al, 2007	There was not a differential effect of the intervention that was dependent on BMI at baseline.
Boys	Jago et al, 2014	Boys in the intervention group obtained 8.6 mins more of weekday MVPA than the control group (95% CI 2.8 to 14.5), with no evidence of an effect for girls.
	Schuna et al, 2013	Boys accumulated significantly more MVPA compared to girls in the same after-school program. This study only measured MVPA achieved during an intervention session and not change in MVPA. There was no control group.
	Herrick et al, 2012	The SPARK programme had no effect on MVPA levels in all participants exposed to the intervention regardless of their gender. Similarly, no gender specific effects of SPARK on MVPA were identified.

Figure 1 Summary of Study Selection Process

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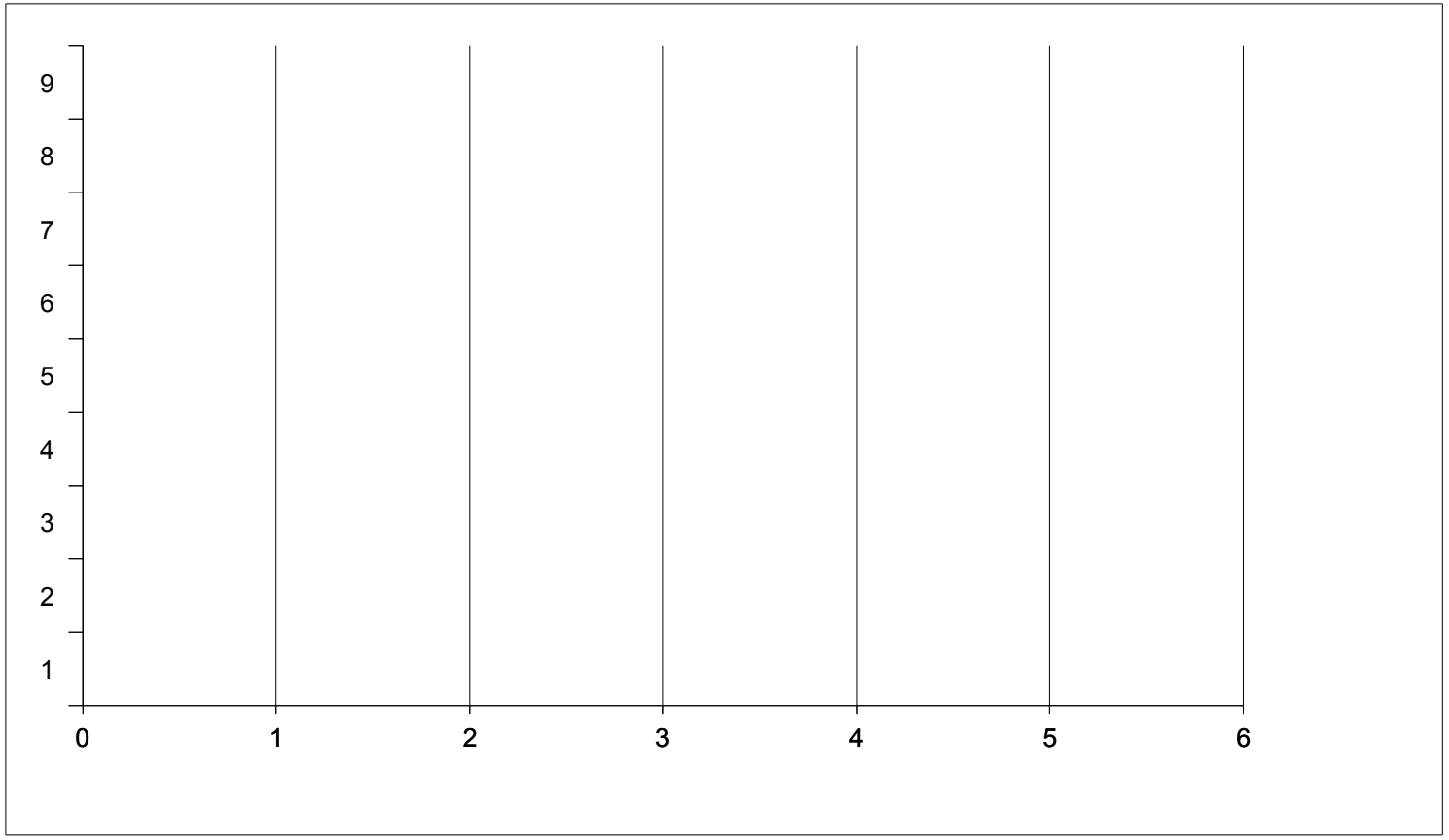
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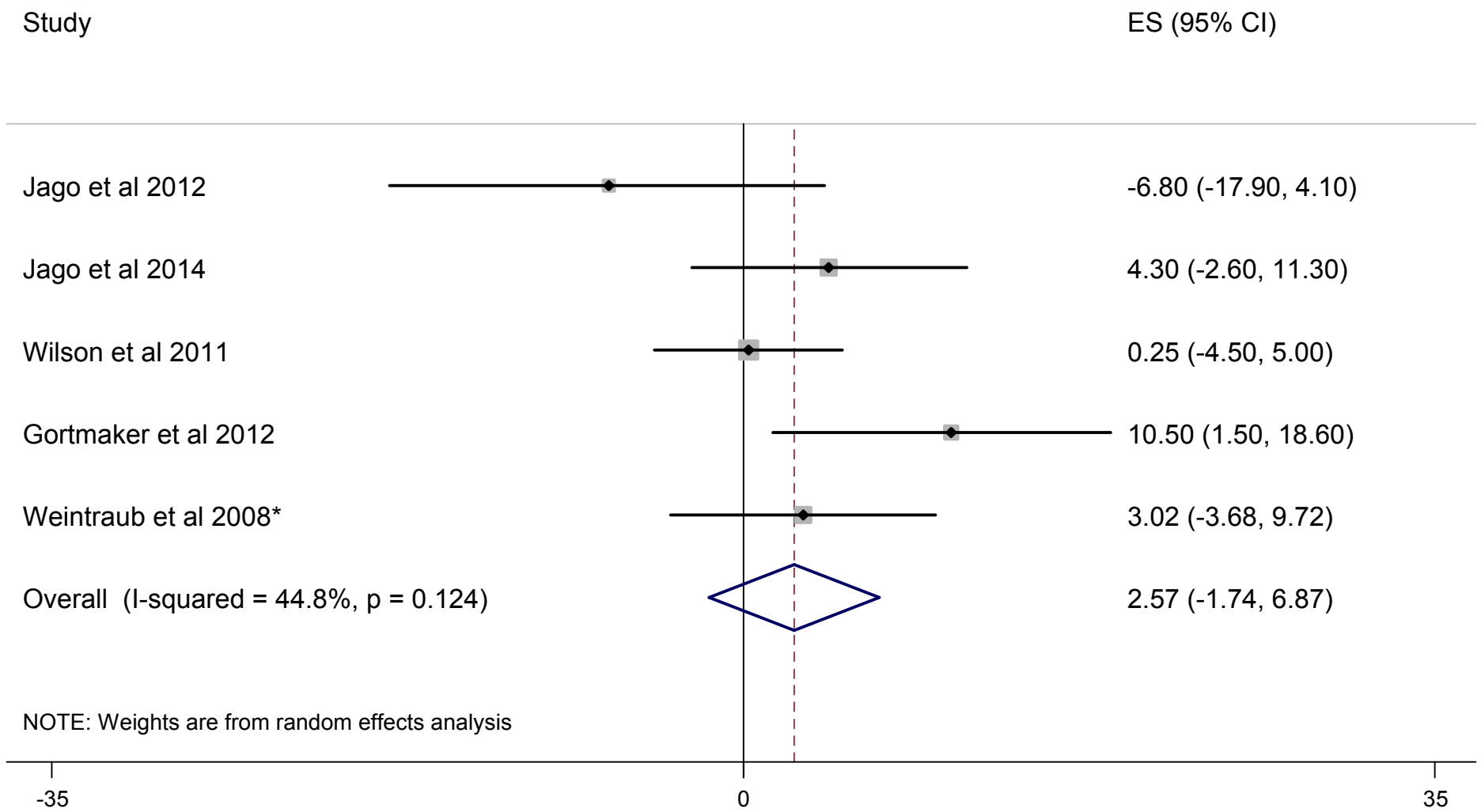
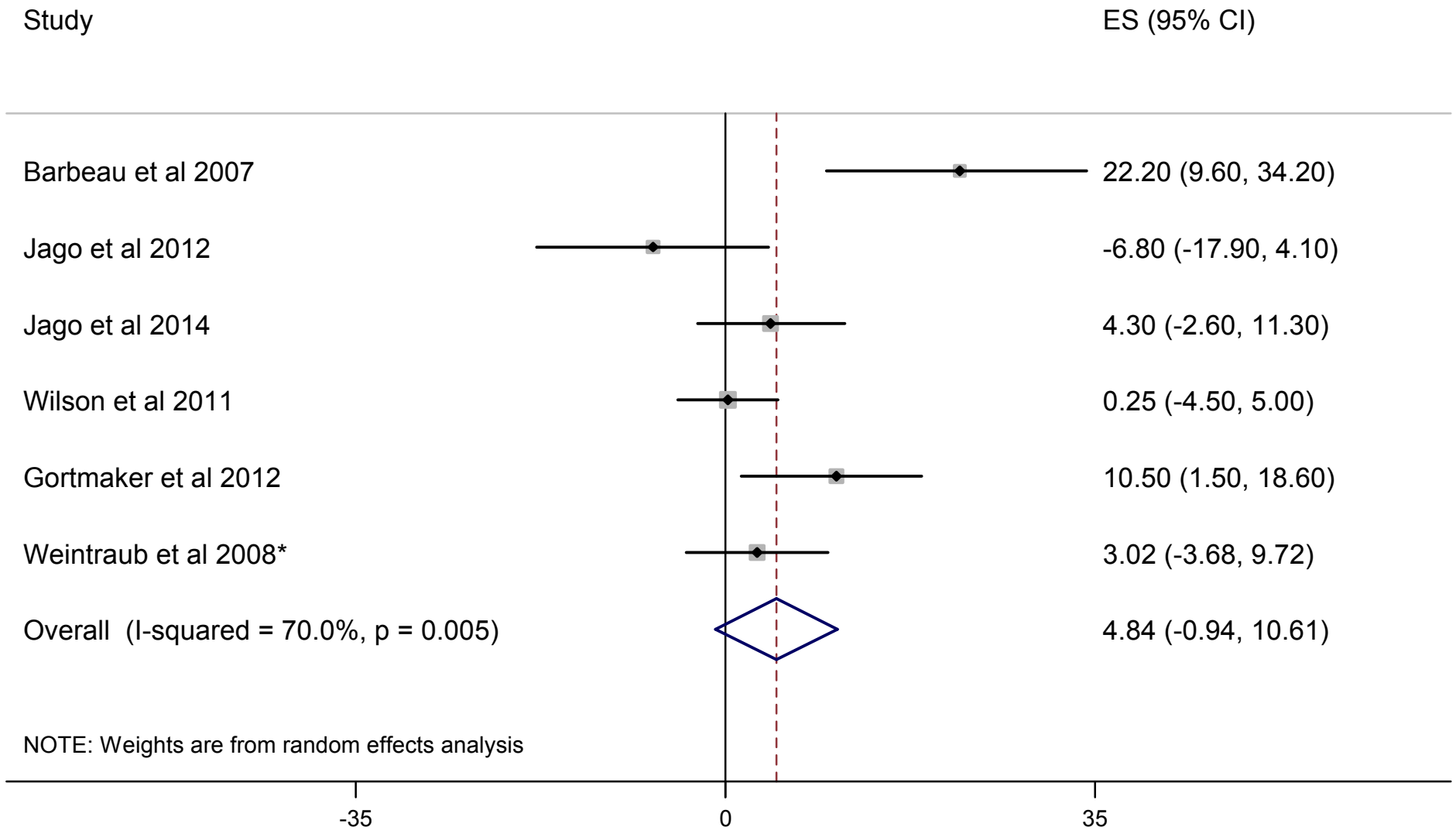
Figure 4 Adjusted mean difference in mins/day of MVPA in I vs C at end-point follow-up: Accelerometer only studies



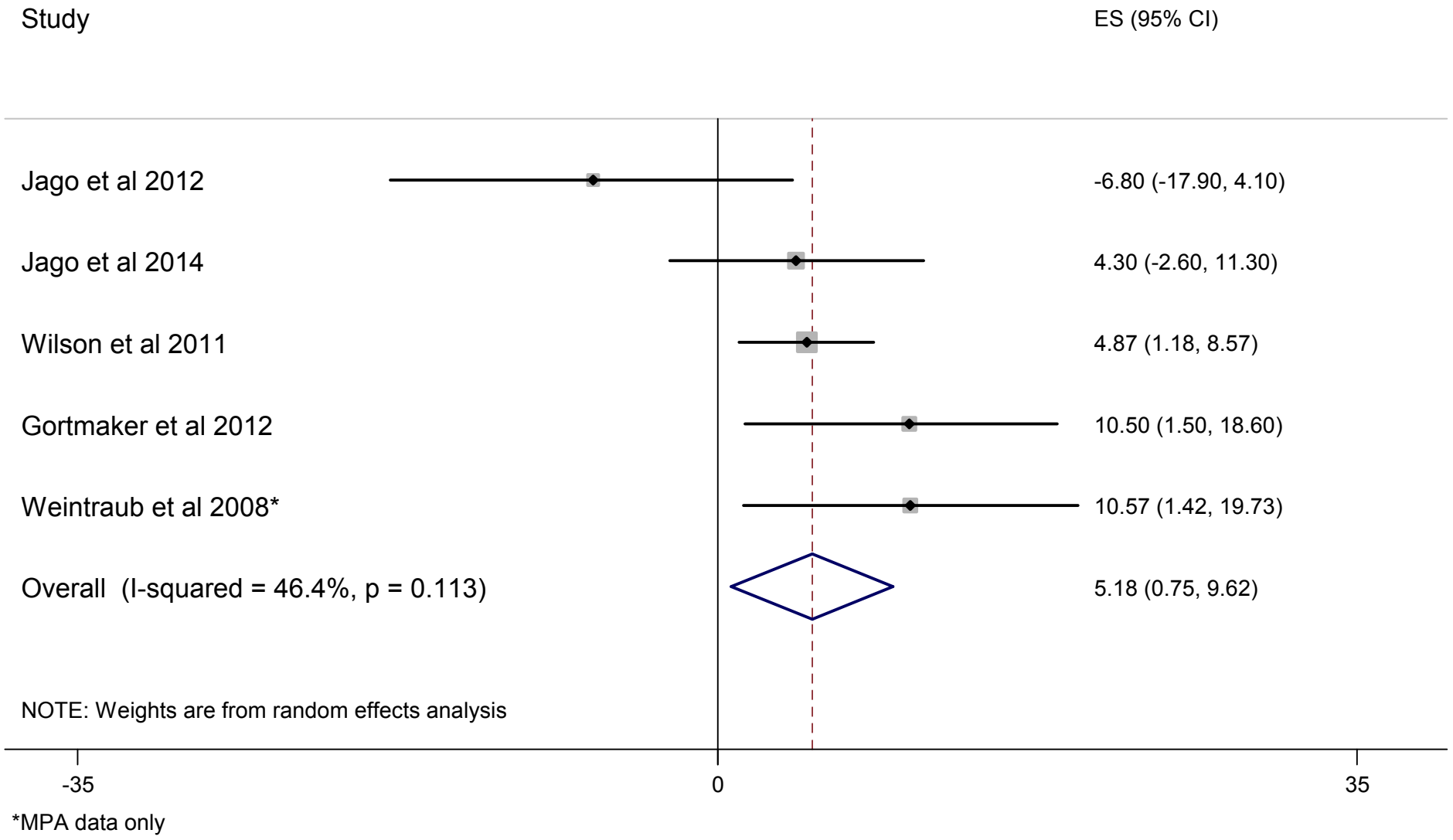
*MPA data only

Figure 5 Adjusted mean difference in mins/day of MVPA in I vs C at end-point follow-up: Self-report and accelerometer studies



*MPA data only

Figure 6 Adjusted mean difference in mins/day of MVPA in I vs C at initial follow-up: Accelerometer only studies



Supplementary Table 1 Study Characteristics

Study	Design	Location	Target Population	Participants n = num analysed (total num at baseline)	Description of Intervention and Control
Individual randomised controlled trial (Individual participants randomized)					
Barbeau et al, 2007	Individual randomised controlled trial	Georgia, USA	Third, fourth, and fifth grade (8-12 years) black girls	**I:** n= 118 (NR*) **C:** n= 83 (NR*) *278 overall pre-tested	**I:** 10 months duration, 110mins session (PA 80mins, homework 30mins) five times per week. PA component: 25mins of skills (dribbling basketball), 35mins planned MVPA (e.g.basketball, tag, softball), 20mins toning and stretching. Subjects wore Polar HR monitors and were taught how to maintain their HR during the 35mins planned MVPA to keep it above 150bpm. Prizes were given out to reward good behaviour, participation and effort. **C:** Subjects in the control group received no intervention.
Story et al, 2003 *GEMS*	Two-arm parallel group, pilot individual randomised controlled study	Minnesota, USA	African-American girls aged 8-10 years old with BMI > 25th percentile for age and sex	**I:** 26 (26) **C:** 27 (28)	**I:** 12 weeks duration, 60mins 'Girlfriends for KEEPS – *Keys for eating, exercising, playing and sharing'* session twice weekly. Sessions involved physical activity (e.g. dancing, jump rope, relay races, African-American games, tag, step aerobics) physical and nutritional education, a healthy snack, chilled bottled water, and a family component (with additional neighbourhood walks, phone calls to parents and family packets sent home). Incentives were built into the program. **C:** 12 weeks duration, monthly Saturday morning meetings (non-nutrition or physical activity themes). Focused on promoting positive self-esteem and cultural enrichment (arts and crafts, self-esteems, memory books, workshops on African

					percussion instruments).
Weintraub et al, 2008 *SPORT*	2-arm, parallel-group, pilot individual randomized controlled trial	Northern California, USA	Fourth and fifth grade students, BMI≥ 85th percentile, low income community	**I:** 9 (9) **C:** 12 (12)	**I:** Six months duration, 135mins session three times a week for first 5 months, increased to four times a week at month 5 on parental / participant request. Within each session; 75mins of soccer-related activity and then homework. At conclusion of program, children received certificates of accomplishment and medals. **C:** Six months duration, once weekly after-school meetings focusing on nutrition and health education.
Cluster randomised controlled trial (schools randomised)					
Wilson et al, 2002	Pilot cluster randomised controlled trial.	Richmond, Virginia, inner-city area, USA	African-American 11-15 year olds children	**I (1):** 14 (NR) **I (2):** 14 (NR) **C:** 11 (NR)	I (1): Social cognitive theory (SCT) only group. 12 weeks duration. After-school intramural sports program Team-Up, 3 days per week. F&V cooking class 1 day per week. Goals: Increase servings of F & V to 6 to 9 per day, increase aerobic activity to 30-60mins/day for 7 days per week. I (2): SCT and strategic self-presentation (motivational intervention) group. Participants took part in all the same components as the SCT only group. In addition, participated in strategic self-presentation videotapes. C: Education-only. 12 weeks duration. Goal: maintain a usual diet and physical activity pattern. Educational materials about general health issues provided.
Jago et al, 2012 *Bristol Girls Dance Project*	Cluster randomised controlled feasibility trial	Bristol, UK	11-12 years girls	Baseline to last week of intervention **I:** n= 72 (90) **C (1)**: n=56 (60) **C (2):** n=53	**I:** 9 weeks duration, 90 minute hip-hop/street dance class twice weekly. The dance class content included opportunities for participant input and time to practice short dance pieces. **C (1):** No dance classes. Schools received incentives for data collection. **C (2):** No dance classes. Schools received incentives for data collection and a delayed dance workshop.

				(60) Baseline to 3 months after intervention ended **I:** n= 61 (90) **C (1):** n=55 (60) **C (2):** n=46 (60)	
Dzewaltowski et al, 2010 *HOP'N*	Nested cross-sectional group randomised controlled effectiveness trial	Kansas, USA	Third or fourth grade students enrolled in pre-existing afterschool programme	**I:** n= 134 (148) **C:** n= 112 (125)	**I:** 3 years duration (baseline year and 2 subsequent intervention years), 2.5 hours 'Healthy Opportunities for Physical Activity and Nutrition' (HOP'N) session every weekday implemented into existing after-school programme. PA component – 30mins organised PA daily following the CATCH Kids Club PA principles. Other components: Daily healthy snack, 60 mins once weekly nutrition and PA education, development of the community/government/human service agency to co-ordinate improving after-school programmes and after-school staff training three times per year. **C:** Existing after-school programme with no HOP'N intervention.
Jago et al, 2014 *ACTION 3:30*	Cluster randomised feasibility trial	Bristol, UK	9 to 11 years old children	**I:** 153 (284) **C:** 157 (255)	**I:** 20 weeks duration, 60mins physical activity session twice weekly, delivered by two teaching assistants from each school, using detailed session plans and an autonomy-supportive style. Every two weeks, pupils were given an information sheet including activity ideas to practise outside the club. £200 of equipment given to each school to provide further resources

					for Action 3:30 club. Gifts were given at data collection points. **C:** No intervention. Received £200 to school fund once data was collected. Gifts were given at data collection points.
Madsen et al, 2013 *SCORES*	Cluster randomized controlled trial	California, USA	Fourth and fifth grade students enrolled in pre-existing after-school programme	**I:** 79 (82) **C:** 71 (74)	**I:** 60mins session four times per week (2 sessions per week soccer and 2 sessions per week creative writing). Game days on Saturdays, providing 1 additional hour of soccer per week. SCORES curriculum and staff training / support provided (incl. soccer coaching manuals with > 100 soccer practice activities and games and a writing program curriculum). **C:** No SCORES curriculum implemented into afterschool programme
Wilson et al, 2011 *Active by Choice Today*	Cluster randomized controlled trial	South Carolina, USA	Sixth grade students	**I:** 673 (729) **C:** 635 (693)	**I:** 17 weeks duration (over 1 year), 120mins session three times per week. Each 'Active by Choice Today (ACT)' intervention session consisted of homework/snack (30mins), student selected planned MVPA activities (60mins), behavioural skills and motivational component to develop strategies for increasing MVPA at home (30mins). **C:** 17 weeks duration (over 1 year), 120mins session three times per week. Each 'General Health Education Program' session consisted of homework/snack (30mins) and three hands-on activities related to general health (90mins). Sessions focussed on nutrition, stress management, drug prevention and drop-out prevention (with no PA component).
Quasi-Experimental					
Herrick et al, 2012 *SPARK*	Quasi-experimental controlled study	California, USA	Fifth grade students enrolled in pre-existing after-school	**I:** n= 47 (48) **C:** n = 51 (52)	**I:** 5 months duration, SPARK curriculum implemented in existing after-school program with staff training and almost 200 pieces of standard SPARK physical activity equipment. Designated PA co-ordinator to support students in PA. Specific details regarding frequency/duration of sessions not provided.

			program		**C:** No SPARK curriculum implemented in existing after-school program. Designated PA co-ordinator to support students in PA.
Gortmaker et al, 2012	Quasi-experimental	Pacific Northwest, Midwest, South and Eastern US	5-11 years old children attending pre-existing YMCA programme	**I:** 114 (NR) **C:** 98 (NR)	**I:** 6 months environmental change (in the areas of physical activity and nutrition) in YMCA afterschool programmes. PA component: 30mins of moderate PA daily, 20mins vigorous PA offered three times per week and strongly encourage staff participation in physical activity. Nutrition component: follow specified healthy eating/drinking policies. Other components: Avoid TV / movies, limit computer time to <1 hour, review advertisements that may be incongruent with healthy eating and physical activity. Details regarding frequency of afterschool sessions not provided. **C:** No environmental change intervention implemented in YMCA afterschool programme
Robbins et al, 2012 *Girls on the move*	Quasi-experimental pilot trial	Midwestern, USA	Sixth and seventh grade girls not meeting national MVPA recommendations	**I:** 18 (37) **C:** 12 (32)	**I:** 6 months duration, 90mins 'Girls on the move' session every weekday (70mins PA, 20mins education). PA component: 5mins warm-up, 60mins planned MVPA, 5mins cooldown. Educational component: 20mins group discussion on healthy eating and PA and homework. Other components: 20mins face to face session with a registered school nurse during the school day every other month for 6 months. **C:** 6 months duration, 90mins afterschool workshop (focusing on caring for my body, fashion, hair and nail tips, sun and food safety, healthy relationship and friendship, building self-esteem and career exploration) once a month. Other component: 20mins face to face session with a registered school nurse during the school day every other month for 6 months.
Other Study Design					

Iversen et al, 2011	Longitudinal	Hawaii, USA	Fourth to sixth grade students	**I:** 119 (NR) No control or comparator group	**I:** Physical component – following the SPARK program. Nutrition component – encouraging fruit and vegetable intake through various activities (e.g. art projects, nutrition booklets, colouring pages). Specific details regarding frequency/duration of sessions not provided.
Ignico et al, 1997	Longitudinal	USA	8 to 11 years old 'low-fit' children (who have failed to meet the body fat and mile walk/run Physical Best fitness standards)	**I:** 13 (13) No control or comparator group	**I:** 10 weeks duration, 60mins aerobic physical activity, three times per week.
Schuna et al, 2013 *Keep It Moving*	Cross-sectional study	Colorado Springs, Colorado USA	Third, fourth, and fifth grade (8-12 years) students in an ethnically diverse low SE status school district.	**I:** n= 116 (119) No control or comparator	**I:** 45-60mins 'Keep It Moving' (KIM) PA session twice weekly. KIM was developed collaboratively by school and community leaders to increase PA. No set curriculum and students were offered structured or unstructured play.